NATIONAL MUSEUM OF THE UNITED STATES AIR FORCE™

Major General Albert Boyd and Major General Fred Ascani

Research and Development Gallery

Teacher Resource Guide

Contents

A product of the NMUSAF Education Division

Major General Albert Boyd and Major General Fred J. Ascani
Research and Development Gallery
An Introduction

The Research and Development Gallery at the National Museum of the US Air Force contains the world's largest and finest collection of test aircraft on display. The Research and Development Gallery's diverse collection ranges from World War II up to the present, and it includes pure research aircraft, prototypes of future production aircraft, and inflight simulators.

Major General Albert Boyd, commonly called the "Father of Modern Air Force Test Flight," had a remarkable career as a test pilot, flying over 700 types of aircraft. He directed the highly successful X-1 program that broke the sound barrier. Many of the experimental aircraft Boyd flew are on display in the Research and Development Gallery including his record setting P-80R.

Major General Fred Ascani, an accomplished combat leader in World War II, became the Director of Experimental Flight Test and Engineering at Edwards AFB, California. He flew some of the aircraft in the Research and Development Gallery, and he managed the XB-70 program (the sole remaining XB-70 is on display).

"X"-Aircraft

X-planes play a unique role in pushing the boundaries of aerospace technology. Designated "X" followed by a number, these pure research vehicles are only built in small numbers. Additional X-Aircraft are also in the Space Gallery.

BELL X-1B

The X-1B was one of a series of rocket-powered experimental airplanes designed to investigate supersonic flight problems. The X-1B's flight research primarily related to aerodynamic heating and the use of small "reaction" rockets for directional control.

Ground test of the X-1B's rocket engine. (NASA photo)

The X-1B made its first powered flight in October 1954. A few months later, the US Air Force transferred the X-1B to the NACA (National Advisory Committee for Aeronautics), predecessor to NASA (National Aeronautics and Space Administration), which conducted the heating and control tests. The X-1B tests played an important role in developing the control systems for the later X-15.

On test missions, the X-1B was carried under a "mother" airplane and released between 25,000-35,000 feet. After release, the rocket engine fired under full throttle for less than five minutes. After all fuel (an alcohol-water mixture) and liquid oxygen had been consumed, the pilot glided the airplane to earth for a landing.

The Bell X-1B underneath its B-29 carrier aircraft.

The X-1B made its last flight in January 1958, and it was transferred to the Museum a year later.

TECHNICAL NOTES:

Engine: Reaction Motors XLR-11-RM-6 four-chamber rocket engine of 6,000 lbs thrust

Maximum speed: 1,650 mph

Maximum altitude: 90,000 ft

Landing speed: 170 mph

Weight: 16,590 lbs loaded

DOUGLAS X-3 STILETTO

The twin-turbojet X-3, the only one built, was designed to test sustained flight at twice the speed of sound. It also explored the use of very short wings and titanium airframe construction.

Engine development difficulties forced the use of lower-powered engines than originally planned, prohibiting the X-3 from achieving its Mach 2 design potential. Even so, data gained from the X-3 program greatly benefited the F-104, X-15, SR-71, and other high performance aircraft.

The X-3 made its first test flight at Edwards Air Force Base, California, in October 1952. The X-3 was transferred to the Museum in 1956.

TECHNICAL NOTES:

Engines: Two Westinghouse J34s of 3,370 lbs thrust each (4,900 lbs thrust with afterburner)

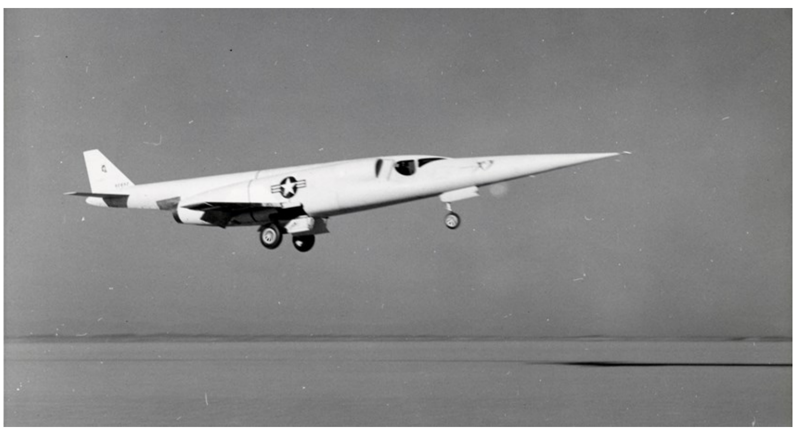
Maximum speed: 650 mph (level flight), but designed for Mach 2

Service ceiling: 38,000 ft

Wingspan: 22 ft 8 in

Length: 66 ft 10 in

Weight: 22,400 lbs maximum



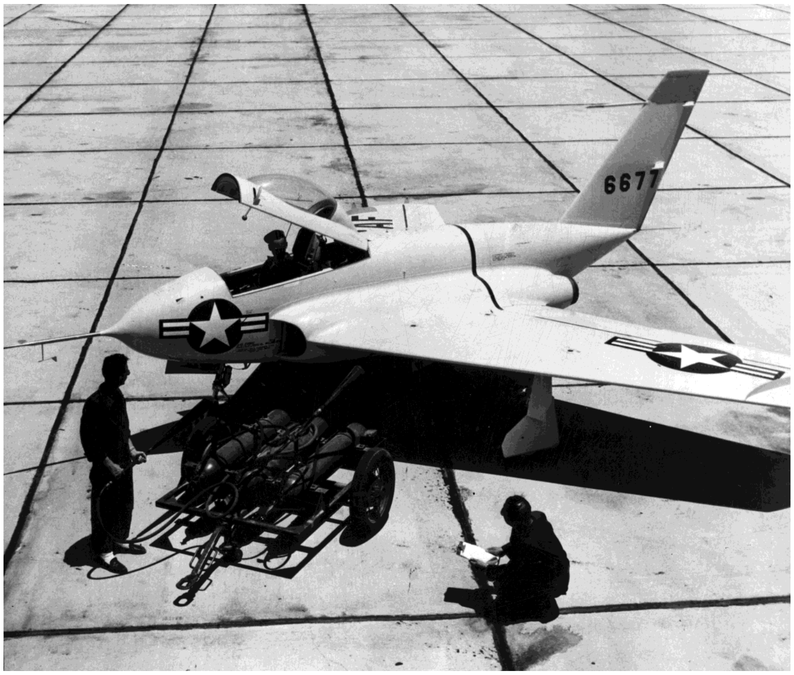
The X-3's fuselage was three times longer than the aircraft's wingspan.

NORTHROP X-4 BANTAM

During World War II, engineers in the US and UK studied semi-tailless aircraft, and the German *Luftwaffe* fielded the semi-tailless Me 163 (one of which is on display in the Museum's World War II Gallery). After the war ended, Northrop built two X-4s to test if this configuration could perform at transonic (near-supersonic) speeds better than conventional aircraft.

Flight testing of the X-4 began in 1948, and in 1950, both X-4s were turned over to the NACA (National Advisory Committee for Aeronautics), predecessor to NASA (National Aeronautics and Space Administration). The first X-4 was grounded after only ten flights, and only the second X-4 (on display here) was used in the joint USAF/NACA program. Instability of the X-4 at high speed led to the conclusion that semi-tailless aircraft were not suitable for transonic flight (with the technology then available).

The X-4 on display was transferred to the Museum shortly after the program ended in 1953. It was restored by the Western Museum of Flight, Hawthorne, California.



Unlike most aircraft of its time, the X-4 did not have a horizontal tail.

TECHNICAL NOTES:

Engines: Two Westinghouse XJ30 turbojet engines of 1,600 lbs thrust each

Maximum speed: 640 mph

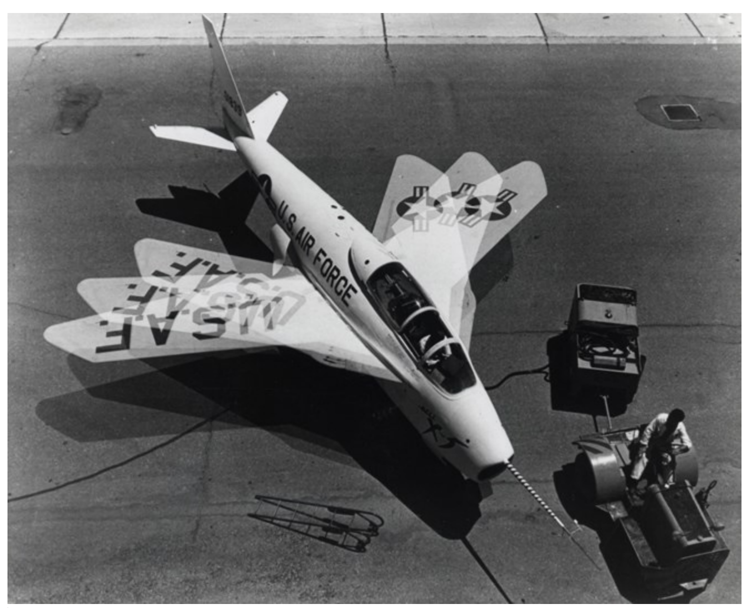
Maximum endurance: 44 minutes

Service ceiling: 44,000

BELL X-5

The X-5 was the world's first high-performance airplane to vary the sweepback of its wings in flight. It investigated the characteristics of variable sweep aircraft in flight and the feasibility of producing aircraft with this feature. The X-5 was based upon the design of a Messerschmitt P. 1101 airplane discovered in Germany at the end of World War II (and which could vary its sweep only on the ground).

Two X-5s were built, and the first flight occurred in June 1951. One of the X-5s was destroyed in October 1953, when it failed to recover from a spin at 60 degrees sweepback. The other was delivered to the Museum in March 1958.



Time lapse photograph showing the X-5's full 20-60 degree wing sweep range. This X-5 was destroyed in a

The Museum's X-5 flying with its wings swept fully forward, which allowed it to take off and land in a shorter distance, land at a lower speed, and climb faster. With the wings swept back, it could fly faster.

TECHNICAL NOTES:

Engine: Allison J35 of 4,900 lbs thrust

Maximum speed: 690 mph

Range: 500 miles

Service ceiling: 50,700 ft

Wingspan: 32 ft 9 in with wings extended; 22 ft 8 in with wings swept

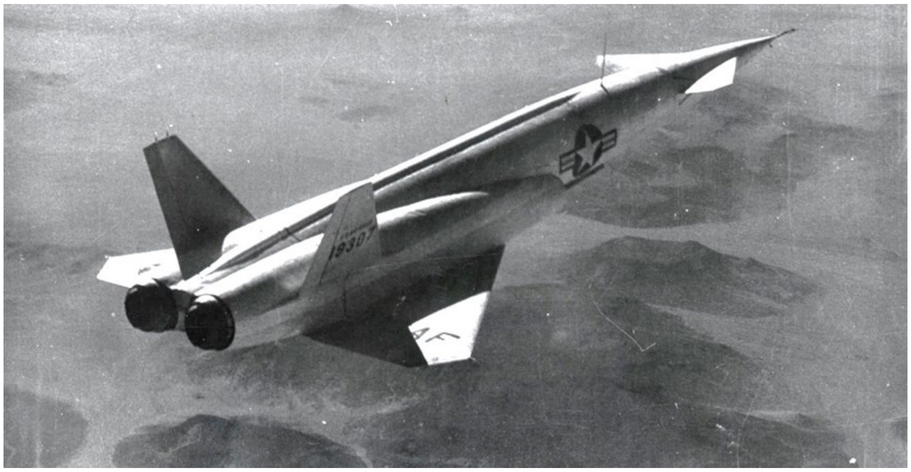
Weight: 9,800 lbs loaded

NORTH AMERICAN X-10

The turbojet-powered X-10 tested flight characteristics and guidance, navigation, and control systems for the planned SM-64 Navaho. The Navaho was intended to be a ramjet-powered, nuclear-armed cruise missile launched by rocket boosters.

North American built thirteen X-10s (ten of which were test flown), and the first X-10 flight occurred in October 1953. Although accidents destroyed several X-10s, the test program proved to be successful. One X-10 flew at Mach 2.05, a remarkable achievement for the time. In 1957, however, the Navaho program was cancelled as InterContinental Ballistic Missile (ICBM) technology matured.

The remaining X-10s were used to support the XB-70 program and as targets for Surface-to-Air Missiles (SAMs) then in development. The Museum's X-10 is the only one still in existence.



The X-10 could be remotely controlled from the ground or another aircraft, or it could guide itself.

TECHNICAL NOTES:

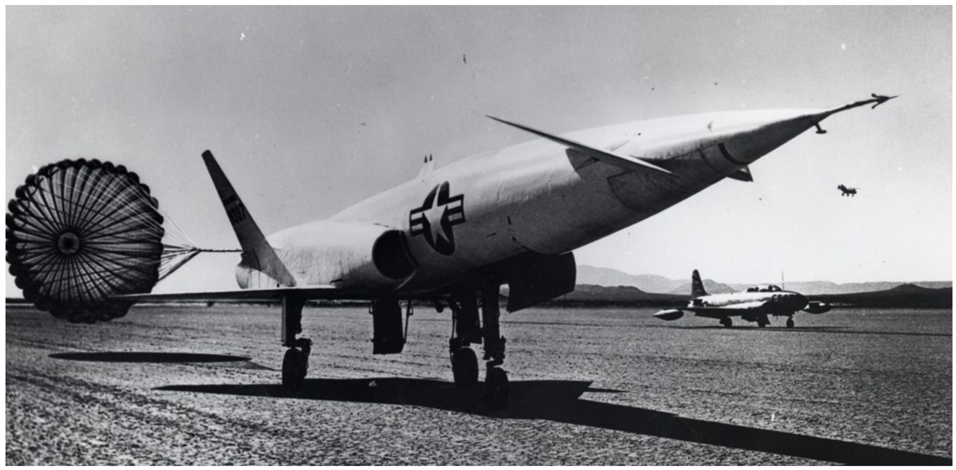
Engines: Two Westinghouse XJ40s of 10,000 lbs thrust each (with afterburner)

Maximum speed: 1,300 mph

Range: 400 miles

Service ceiling: 45,000 ft

Weight: 40,000 lbs



The X-10 took off and landed on its own undercarriage and deployed a parachute to shorten its landing roll.

GRUMMAN X-29A

In 1985, the X-29A on display became the world's first forward-swept aircraft to fly supersonically. The X-29A program explored cutting-edge aircraft design features, including forward-swept wings, advanced materials, a forward-mounted elevator (or canard), and a computerized flight control system. It was managed by the US Air Force and funded by DARPA (Defense Advanced Research Projects Agency), the USAF, and NASA.

During World War II, Germany and the United States experimented with forward-swept wings, but both encountered problems with the metal wings bending dangerously at higher speeds. As stronger composite materials became available in the 1970s, however, wing structures could be both lightweight and very rigid.

The Museum's aircraft is the first of two X-29As built by Grumman, and it made its first flight in December 1984. The second X-29A first flew in 1989 and continued to perform test flights into the early 1990s.

TECHNICAL NOTES

Engine: General Electric F404 turbofan engine of 16,000 lbs thrust

Maximum speed: 1,200 mph

Maximum endurance: 60 minutes

Service ceiling: 55,000 ft

Weight: 17,303 lbs maximum

After successfully completing the test program, the X-29A on display was retired to the Museum in late 1994.

NASA/BOEING X-36

In the mid-1990s, NASA and the Boeing (then McDonnell Douglas) "Phantom Works" built two unmanned X-36 Tailless Fighter Agility Research Aircraft to develop technology for a maneuverable, tailless fighter. The X-36s were about a quarter of the size of a potential future fighter.

Though two were built, only the Museum's X-36 actually flew. The first X-36 flight occurred in May 1997, and the flight test program met or exceeded all of the project's goals—a remarkable achievement.

The next year, the USAF's Air Force Research Laboratory (AFRL) used the Museum's X-36 to test its RESTORE (Reconfigurable Control for Tailless Fighter Aircraft) software. AFRL developed this software to save a tailless fighter in case its control system was damaged or malfunctioned. In December 1998, the X-36 made two successful RESTORE flights. The X-36 on display came to the Museum in April 2003. The X-36 "cockpit" and forward fuselage areas were autographed by personnel associated with the program before Boeing donated the aircraft to the Museum.

TECHNICAL NOTES

Engine: Williams International F112 turbojet engine of about 700 lbs thrust

Maximum speed: 234 mph

Highest flight: 20,200 ft

Gross weight: 1,245 lbs

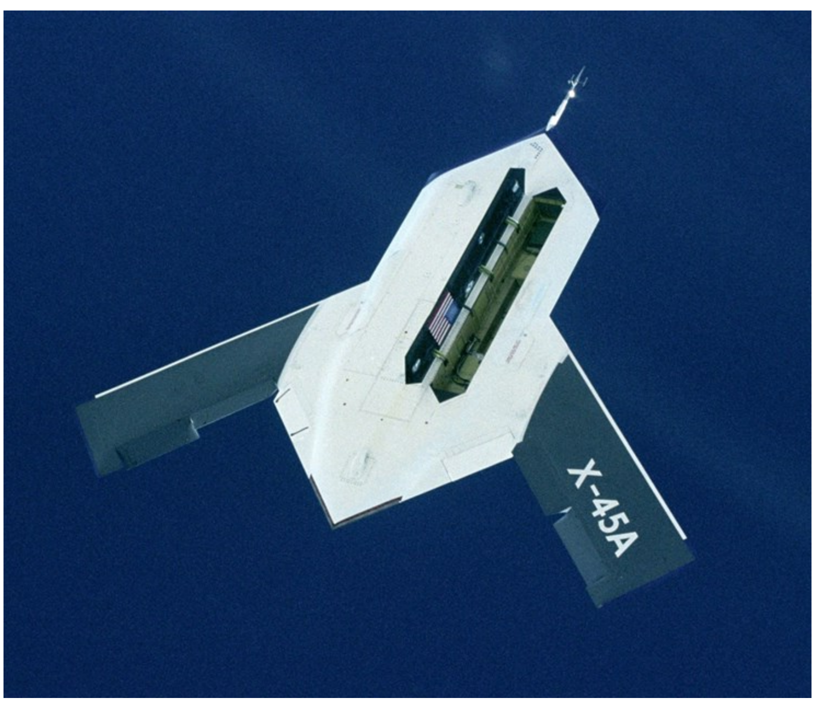
BOEING X-45A J-UCAS (Joint Unmanned Combat Air System)

The pioneering X-45A demonstrated that highly autonomous uninhabited aircraft could be used to attack opposing surface-to-air defenses (called Suppression of Enemy Air Defense or SEAD). Begun by the Defense Advanced Research Projects Agency (DARPA), the program was later managed by the US Air Force and US Navy. During the test program, the stealthy X-45A accomplished many significant achievements in aviation history.

In September 2000, Boeing's "Phantom Works" completed the first of two X-45As, using research from its manned Bird of Prey aircraft. The first X-45A made its first flight in May 2002 and the second vehicle followed in November. In April 2004, an X-45A hit a ground target with an inert, precision-guided weapon. In August 2004, for the first time, one pilot-operator successfully controlled two X-45As in flight.

In 2005, the X-45As autonomously flew a pre-planned SEAD mission against simulated Surface-to-Air Missile (SAM) systems. The X-45As then used their on-board, decision-making software to avoid a new, unplanned SAM threat. They independently determined which aircraft would attack the new target based upon their position, weapons, and fuel. After the pilot-operator at Edwards Air Force Base, California, checked the plan created by the UCAS's software, the X-45As successfully attacked and returned to base.

The X-45A on display, the second one built, came to the museum in August 2006.



TECHNICAL NOTES:

Armament: Eight Small Diameter Bombs (carried in two weapons bays)

Engine: Honeywell F124-GA-100 turbofan of 6,500 lbs thrust

Cruising speed: About 610 mph

Maximum Payload: 4,500 lbs

Ceiling: 40,000 ft

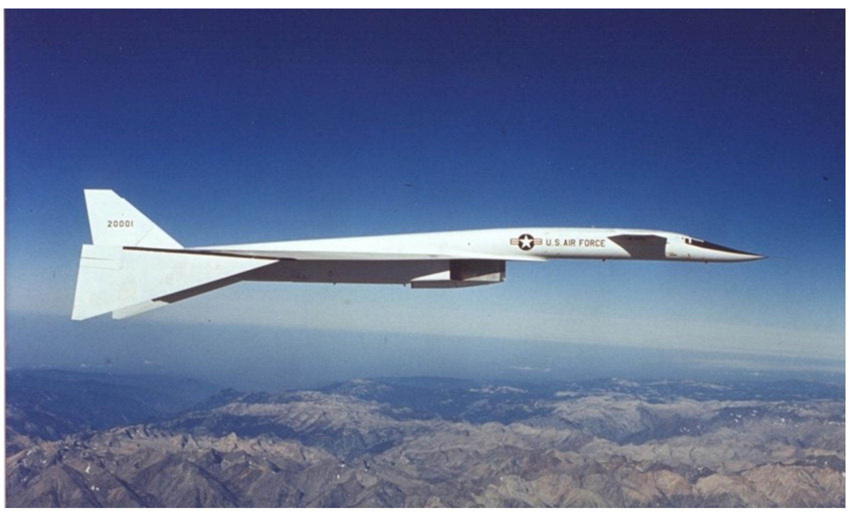
Weight: 12,190 lbs

NORTH AMERICAN XB-70A VALKYRIE

The futuristic XB-70A was originally conceived in the 1950s as a high-altitude, nuclear strike bomber that could fly at Mach 3 (three times the speed of sound)—any potential enemy would have been unable to defend against such a bomber.

By the early 1960s, however, new Surface-to-Air Missiles (SAMs) threatened the survivability of high-speed, high-altitude bombers. Less costly, nuclear-armed ICBMs (InterContinental Ballistic Missiles) were also entering service. As a result, in 1961, the expensive B-70 bomber program was canceled before any Valkyries had been completed or flown.

Even so, the USAF bought two XB-70As to test aerodynamics, propulsion, and other characteristics of large supersonic aircraft. The first XB-70A, on display here, flew in September 1964, and it achieved Mach 3 flight in October 1965. The second Valkyrie first flew in July 1965, but in June 1966, it was destroyed following an accidental mid-air collision. The third Valkyrie was not completed. The first XB-70A airplane continued to fly and generate valuable test data in the research program until it came to the Museum in 1969.



The sleek Valkyrie took advantage of "compression lift," where the shock wave generated by the airframe at supersonic speed supports part of the airplane's weight. The XB-70A could also droop its wingtips as much as 65 degrees for additional stability at high speeds.

The Valkyrie's airframe was built with advanced techniques and materials to reduce weight and to withstand high temperatures from aerodynamic heating at high speeds.

The Valkyrie's six large turbojet engines together provided an impressive 180,000 pounds of thrust.

TECHNICAL NOTES:

Engines: Six General Electric YJ93s of 30,000 lbs thrust each with afterburner

Maximum speed: 2,056 mph (Mach 3.1) at 73,000 ft

Range: 4,288 miles

Service ceiling: 77,350 ft

Length: 185 ft 10 in

Height: 30 ft 9 in

Weight: 534,700 lbs loaded

VSTOL Aircraft

VSTOL (Vertical/Short TakeOff and Landing) aircraft combine helicopters' vertical takeoff capability with the speed and range of conventional airplanes.

RYAN X-13 VERTIJET

The X-13 was built to prove the concept that a jet could take off vertically, transition to horizontal flight, and return to vertical flight for landing.

Equipped with a temporary tricycle landing gear, the first of two X-13s flew conventionally in December 1955 to test its overall aerodynamic characteristics. It was then fitted with a temporary "tail sitting" rig, and in May 1956, this X-13 flew vertically to test its hovering qualities.

The Museum's X-13 making a test flight in 1957. The X-13 "landed" by hooking onto a cable at the top of the raised platform. This trailer-mounted platform could then be lowered to a horizontal position.

The second X-13—on display here—made history in April 1957, when it completed the first full-cycle flight at Edwards Air Force Base, California. It took off vertically from its mobile trailer, rose into the air, nosed over into a level attitude, and flew for several minutes. Then, it reversed the procedure to vertical flight and slowly descended to its trailer for a safe landing. This X-13 also made demonstration flights in the Washington, D.C., area later that year.

Contemporary illustration showing the transition from vertical to horizontal flight.

TECHNICAL NOTES:

Engine: Rolls-Royce Avon of 10,000 lbs thrust

Maximum speed: 350 mph

Minimum speed: 0 mph

Service ceiling: 20,000 ft

Weight: 7,200 lbs maximum

Even though the X-13 successfully proved the original concept, its design had limited operational potential, and a lack of funding shut down the program in 1958. The X-13 was transferred to the Museum in 1959.

BELL HELICOPTER TEXTRON XV-3

The product of a 1951 joint US Air Force-US Army initiative, the Bell XV-3 became the world's first successful Vertical Short TakeOff and Landing (VSTOL) tilt-rotor aircraft. By combining the takeoff and hovering capabilities of a helicopter with the speed and range of a fixed-wing aircraft, the XV-3 offered great military potential.

Bell completed two XV-3s and began hover tests in 1955. The first XV-3 was damaged beyond repair, but testing continued with the second aircraft. The first complete conversion from takeoff to horizontal flight and back—the first ever for a tilt-rotor aircraft—took place in December 1958.

The XV-3 did not go into production, but it paved the way for the modern tilt-rotor CV-22 Osprey. After testing ended in 1965, the surviving XV-3 went on display at Fort Rucker, Alabama, and later into storage. In 2004, the XV-3 was moved to the Bell Helicopter Textron facility at Arlington, Texas, where a group of current and retired Bell engineers restored the aircraft. It arrived at the museum in 2007.

Like a helicopter, tilt-rotor aircraft use their propellers, or proprotors, for vertical lift (left). The proprotors then rotate forward for thrust, and the wings provide lift (right). (Images courtesy of Bell Helicopter Textron)

TECHNICAL NOTES:

Engine: Pratt & Whitney R-985

Maximum speed: 184 mph

Wingspan: 31 ft 4 in (rotor tip to rotor tip: 52 ft 6 in)

Length: 30 ft 4 in

Bell Helicopter Textron XV-3 cockpit view in the Research and Development Gallery.

HAWKER SIDDELEY XV-6A KESTREL

The British-built Kestrel was a prototype Vertical/Short TakeOff and Landing (VSTOL) aircraft successfully tested in the 1960s. An improved version, known as the Harrier, became the world's first operational VSTOL fighter when it entered Royal Air Force (RAF) service in 1969.

The first Kestrel began flight trials in 1961 in Britain. The next year, the United Kingdom, US, and the Federal Republic of Germany ordered nine aircraft for combined testing by those countries' representatives. A joint evaluation squadron, which included USAF pilots, conducted Kestrel trials in 1965.

Six of these trial aircraft came to the United States where the US armed forces conducted additional testing. Although the US Air Force did not order it, the US Marine Corps and RAF operated the follow-on Harrier for several decades. The Kestrel on display was delivered to the Museum from Edwards Air Force Base, California, in 1970.

TECHNICAL NOTES:

Armament: None

Engine: Bristol Siddeley Pegasus 5 of 15,200 lbs thrust

Weight: 15,500 lbs maximum

Maximum speed: 650 mph

The Kestrel could operate from grass, semi-prepared surfaces, or ship decks, offering great operational flexibility. Four adjustable exhaust nozzles beneath the wing rotated to provide thrust for vertical, backward, or hovering flight as well as conventional forward movement.

CHANCE-VOUGHT/LTV XC-142A

Five tilt-wing XC-142As were built in the 1960s to explore the suitability of Vertical/Short TakeOff and Landing (VSTOL) transports. VSTOL transports permit rapid movement of troops and supplies into and out of unprepared areas. XC-142As were tested extensively by the US Army, US Navy, US Air Force, and NASA.

An XC-142A first flew conventionally in September 1964 and performed its first transitional flight (vertical takeoff, changing to forward flight, and landing vertically) in January 1965. In tests, XC-142As were flown from airspeeds of 35 mph backwards to 400 mph forward.

Although the XC-142A did not go into production, it foreshadowed future operational VSTOL transports like the V-22 Osprey. The aircraft on display—the only remaining XC-142A—was flown to the Museum in 1970.

TECHNICAL NOTES:

Engines: Four General Electric T64s of 3,080 hp each

Maximum speed: 400 mph

Cruising speed: 235 mph

Range: 820 miles

Service ceiling: 25,000 ft

Weight: 41,500 lbs maximum

With the wings tilted up, an XC-142A took off and landed like a helicopter. The wings could be tilted forward to provide the speed of a fixed-wing aircraft. The engines were linked together so that a single engine could turn all four propellers and the tail rotor (the tail rotor provided pitch control while in vertical flight).

Avro Canada VZ-9AV Avrocar

The Avrocar was the result of a Canadian effort to develop a supersonic, vertical takeoff and landing (VTOL) fighter-bomber in the early 1950s. However, its circular shape gave it the appearance of a "flying saucer" out of science fiction movies of the period.

A.V. Roe (Avro) Aircraft Limited (later Avro Canada) based its design concept for the Avrocar on using the exhaust from turbojet engines to drive a circular "turborotor" which produced thrust. By directing this thrust downward, the turborotor would create a cushion of air (also known as "ground effect") upon which the aircraft would float at low altitude. When the thrust was directed toward the rear, the aircraft would accelerate and gain altitude.

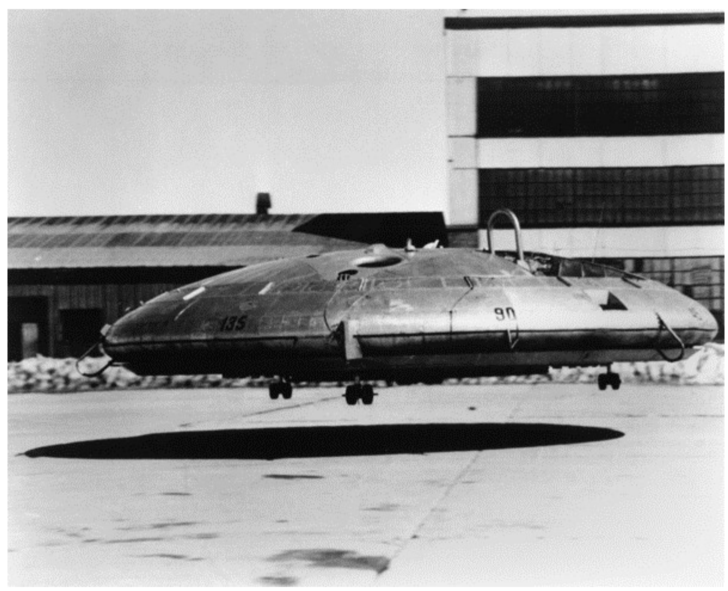
In 1952, the Canadian government provided initial funding but dropped the project when it became too expensive. Avro offered the project to the US government, and the US Army and US Air Force took it over in 1958. Each service had different requirements: the Army wanted to use it as a subsonic, all-terrain troop transport and reconnaissance craft, but the USAF wanted a VTOL aircraft that could hover below enemy radar then zoom up to supersonic speed. Avro's designers believed they could satisfy both services, but these two sets of requirements differed too much.

Research data originally indicated that a circular wing might satisfy both the Army's and Air Force's requirements, and Avro built two small test vehicles to prove the concept. Designated the VZ-9AV Avrocar ("VZ" stood for "experimental vertical flight," "9" for the ninth concept proposal, and "AV" for Avro).

Tests with scale models at Wright-Patterson AFB, Ohio, indicated that the cushion of air under the Avrocar would become unstable just a few feet off the ground. The aircraft would be incapable of reaching supersonic speeds, but the testing went ahead to determine if a suitable aircraft could be developed for the Army. The first prototype–the Avrocar on display (serial number 58-7055)–was sent to the National Aeronautics and Space Administration (NASA) Ames Research Center at Moffett Field, California. There, wind tunnel tests proved that the aircraft had insufficient control for high speed flight and was aerodynamically unstable.

Before free-flight tests, the Avrocar was flown with tethers, seen here in front and behind the aircraft, for safety reasons.

When flown without tethers, the Avrocar was unstable and could reach top speed of only 35 mph.



The second Avrocar prototype underwent flight tests that validated the wind tunnel tests. If it flew more than three feet above the ground, the Avrocar displayed uncontrollable pitch and roll motions, which the Avro engineers called "hubcapping." The Avrocar could only reach a maximum speed of 35 mph, and all attempts to end the hubcapping failed. The project was cancelled in December 1961.

The second prototype aircraft went to the US Army Transportation Museum at Fort Eustis, Virginia, and the first prototype Avrocar came to the National Museum of the US Air Force in 2007.

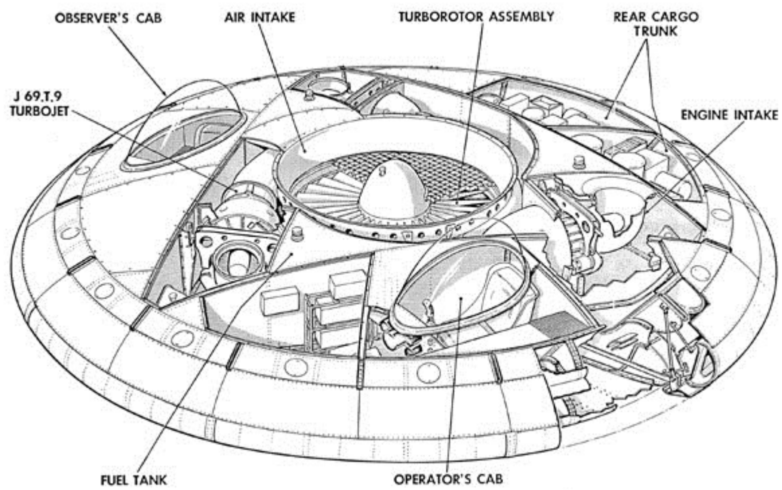
TECHNICAL NOTES:

Engines: Three Continental J69-T9 turbojets of 927 lbs thrust each

Wingspan: 18 ft

Height: 4 ft 10 in

Weight: 4,620 lbs empty



Cutaway drawing of the Avrocar showing its major components.

Prototype Aircraft

The Research and Development Gallery contains many rare or unique prototype aircraft that never went into large-scale production.

BELL P-59B AIRACOMET

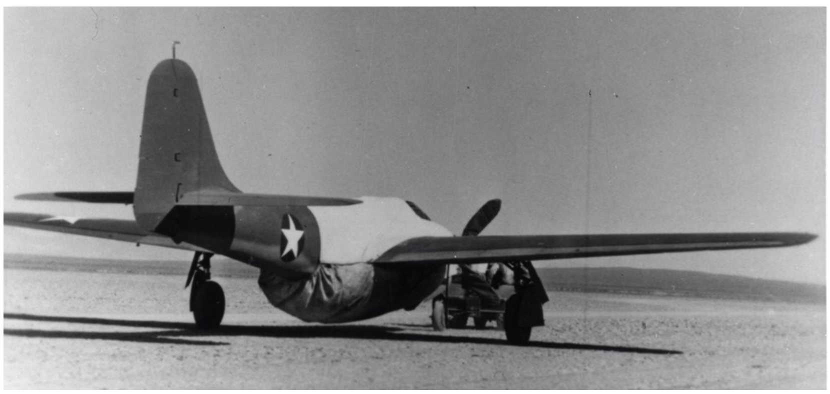
Designed and built in great secrecy during World War II, the P-59 was America's first jet aircraft. Although it never saw combat, the Airacomet provided training for USAAF personnel and invaluable data for the development of higher performance jet airplanes.

The P-59 was powered by two General Electric turbojets developed from the British Whittle engine. Unfortunately, the relatively low thrust of the XP-59's engines and its heavy, conventional airframe design resulted in disappointing performance.

Bell built 50 P-59A and P-59B production aircraft, some of which were flown by the 412th Fighter Group, the US's first jet fighter unit. The P-59B on display was obtained from Kirtland Air Force Base, New Mexico, in February 1956.

One of three XP-59A prototypes. The first prototype XP-59A flew in the fall of 1942 at Muroc Dry Lake (now Edwards Air Force Base), California.

To maintain secrecy, prototype Airacomets were towed to and from the flightline with a fake propeller and a cover over the engine exhausts and intakes.



TECHNICAL NOTES:

Weight: 10,532 lbs loaded

Armament: One 37mm cannon and three .50-cal machine guns

Engines: Two General Electric J-31s of 1,650 lbs thrust each

Maximum speed: 450 mph

Range: 440 miles

Service ceiling: 43,400 ft

FISHER P-75A EAGLE

The Fisher Body Division of General Motors developed the P-75 Eagle to fill an urgent need for an interceptor early in World War II. The original P-75 design incorporated the most powerful inline engine available and components from other aircraft as a way to expedite production.

TECHNICAL NOTES:

Armament: Ten 50-cal machine guns and two 500-lb bombs

Engine: Allison V-3420 of 2,885 hp

Maximum speed: 430 mph

Range: 2,600 miles

Service ceiling: 36,400 ft

Weight: 19,420 lbs loaded

The first two XP-75 prototypes had P-40 wing panels, an A-24 tail, and F4U Corsair landing gear. This design also featured two contra-rotating propellers and dual drive shafts connected to the massive 24-cylinder engine located behind the cockpit.

Flight tests in late 1943 revealed unsatisfactory performance with the first two XP-75 prototypes. At the same time, the Eagle's mission was changed to long-range escort. Ultimately, the idea of using other aircraft components had to be abandoned.

Fisher continued development of the design with the heavily-modified P-75A. By the fall of 1944, however, the US Army Air Forces already had capable escort aircraft like the P-51 Mustang and P-47 Thunderbolt, and it canceled the order for 2,500 P-75As. Only eight XP-75s and six P-75As were built.

The P-75A reflected major changes to the Eagle design that included a larger, squared-off wing, a much larger tail, and a bubble-top canopy

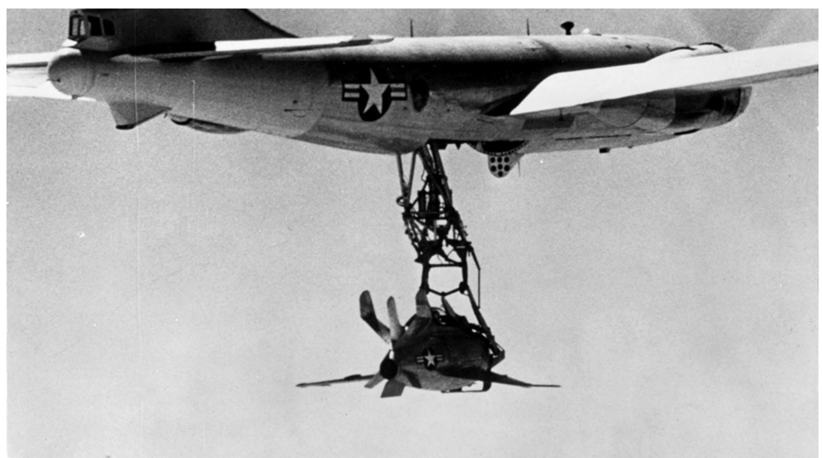
MCDONNELL XF-85 GOBLIN

The McDonnell Aircraft Corporation developed the XF-85 Goblin "parasite" fighter to protect B-36 bombers flying far beyond the range of conventional escort fighters. The "parent" B-36 would carry the XF-85 within a bomb bay—if enemy fighters appeared, the Goblin would be lowered on a trapeze and released to combat the attackers. Once the enemy had been driven away, the Goblin would return to the B-36, re-attach to the trapeze, and be lifted back into the bomb bay.

Two test aircraft were ordered in October 1945, and flight testing with a modified B-29 began in 1948. Test pilots could successfully launch the XF-85, but the turbulent air under the B-29 made recovery difficult and hazardous. About half of the Goblin flights ended with emergency ground landings after the test pilot could not hook up to the B-29.

No XF-85s were ever launched or carried by a B-36. The program ended in late 1949 when aerial refueling of conventional fighter aircraft showed greater promise. The XF-85 was transferred to the Museum in 1950.

Early conceptual mock-up of the Goblin and the B-36 trapeze system. To recover, the pilot guided the retractable hook in front of the cockpit onto the striped bar of the trapeze.



XF-85 fully lowered on its trapeze during a test flight from a B-29. The Goblin had no landing gear, but it had a steel skid under the fuselage and small runners on the wingtips for emergency landings.

TECHNICAL NOTES:

Crew: One

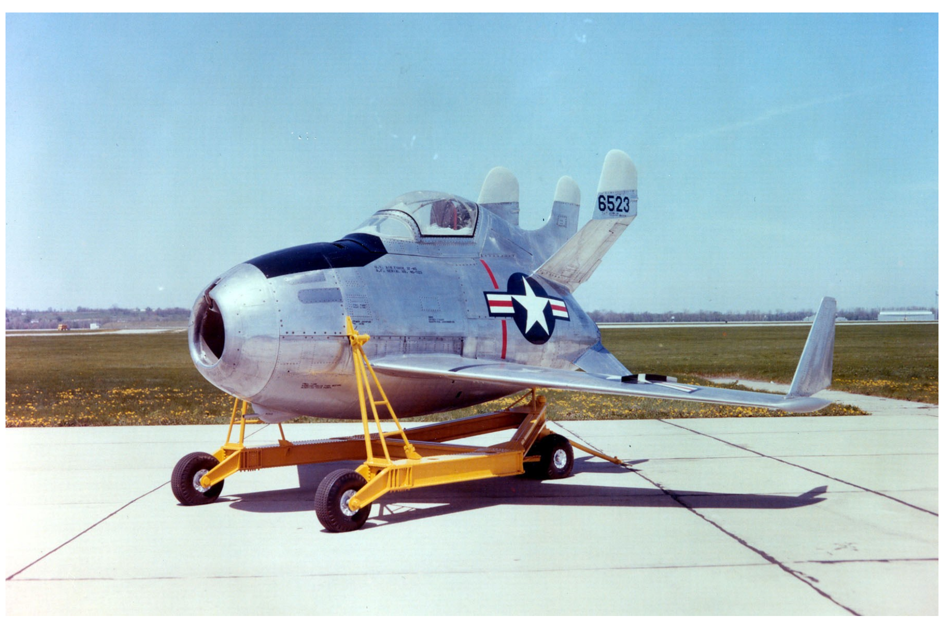
Armament: Four .50-cal machine guns

Engine: One Westinghouse XJ-34 turbojet of 3,000 lbs thrust

Maximum speed: 650 mph

Weight: 4,550 lbs

Maximum endurance: 1 hr 20 min



REPUBLIC XF-84H

The turboprop-driven XF-84H—a joint Air Force/Navy project—was designed to combine the speed of jet aircraft with the long range, low fuel consumption, and low landing speed of propeller-driven aircraft. The XF-84H's modified F-84F airframe included a T-tail and a triangular fin behind the cockpit to reduce the effect of torque from the propellers.

Between July 1955 and October 1956, two XF-84Hs made 12 test flights—11 of these flights ended with emergency landings. Although the XF-84H was one of the fastest single-engine, propeller-driven aircraft ever built, it never approached supersonic speed. Due to poor performance and high maintenance requirements, the XF-84H never became operational.

The aircraft on display was the first of the two prototypes produced by Republic, and it flew 8 of the 12 test flights. The Museum obtained the aircraft from Kern County, California, in 1999.

The XF-84H's rapidly-spinning propellers broke the speed of sound, producing extremely loud shock waves that caused nausea, headaches, and even incapacitation among ground crews. This trait earned the XF-84H the unofficial nickname "Thunderscreech."

TECHNICAL NOTES:

Engine: Allison XF-40-A-1 turboprop of 5,850 shaft hp

Maximum speed: 520 mph

Range: Beyond 2,000 miles

Service ceiling: Above 40,000 ft

Weight: 17,892 lbs

LOCKHEED YF-12A

The YF-12 was developed in the 1960s as a high-altitude, Mach 3 interceptor to defend against supersonic bombers. Based on the A-12 reconnaissance aircraft, the YF-12A became the forerunner of the highly-sophisticated SR-71 strategic reconnaissance aircraft.

The first of three YF-12s flew in August 1963. In May 1965, the first and third YF-12s set several records, including a speed record of 2,070.101 mph and an altitude record of 80,257.65 feet. For their speed record flight, Col Robert L. "Fox" Stephens (pilot) and Lt Col Daniel Andre (fire control officer) received the 1965 Thompson Trophy.

Though the aircraft performed well, the F-12 interceptor program ended in early 1968. High costs, the ongoing war in Southeast Asia, and a lower priority on air defense of the US all contributed to the cancellation.

The aircraft on display—the second one built—was recalled from storage in 1969 for a joint USAF/NASA investigation of supersonic cruise technology. It was flown to the museum in 1979, and it is the only remaining YF-12A in existence (the first YF-12A was damaged beyond repair after a landing mishap and the third YF-12A was destroyed after the crew ejected to escape an inflight fire).

Because air friction heated the skin to more than 500 degrees Fahrenheit, titanium alloys make up 93 percent of the YF-12's structural weight. The YF-12 is also coated with a special black paint that helps radiate heat from its skin.

TECHNICAL NOTES:

Armament: Three Hughes AIM-47A missiles

Engines: Two Pratt & Whitney J58s of 32,000 lbs thrust each (with after-burner)

Crew: Two

Maximum speed: Mach 3+

Range: 2,000+ miles

Service ceiling: above 80,000 ft

Weight: 127,000 lbs loaded

In-Flight Simulators

In-flight simulators can be programmed to mimic the flight characteristics of a wide range of aircraft, and they have become essential in the development of new aircraft.

LOCKHEED NT-33A

The NT-33A was an in-flight simulator operated for decades in support of numerous Department of Defense projects. The NT-33A was used to study flying qualities, cockpit displays, control sticks, and flight control design of many, widely-varied aircraft, including the X-15, A-10, F-15, F-16, F-18, F-117, and F-22. It also trained hundreds of US Air Force and Navy test pilots.

Modified from a standard T-33 trainer in the late 1950s, the NT-33A could be programmed to simulate the flight of a completely different aircraft. It also had an "artificial feel" system that replicated the characteristics of the stick and rudder controls of the aircraft being simulated.

A civilian contractor—the Calspan Corporation (formerly the Cornell Aeronautical Laboratory)—modified, operated, and maintained the aircraft. During the NT-33A's 40 years of distinguished service, Calspan performed numerous research programs around the country. The NT-33A conducted its last research project in April 1997, and it was placed on display at the Museum in August 1997.

When the evaluation pilot in the front seat moved the controls, the NT-33A responded as would the simulated aircraft. The rear seat was occupied by a safety pilot whose standard controls enabled him to fly the aircraft in case the computer malfunctioned or if the simulation proved too difficult to control.

TECHNICAL NOTES:

Maximum speed: 525 mph

Cruising speed: 455 mph

Range: 1,000 miles

Service ceiling: 45,000 ft

CONVAIR NC-131H TOTAL IN-FLIGHT SIMULATOR (TIFS)

This one-of-a kind aircraft was an important in-flight simulator primarily used to study how an aircraft would handle before building an expensive, full-scale prototype. It was created for the US Air Force in the late 1960s by the Cornell Aeronautical Laboratory of Buffalo, New York (later the Calspan Corporation).

Engineers found the TIFS especially useful for studying how large aircraft would handle during takeoff and landing. Vertical fins on the wings generated side forces to simulate crosswinds and provided test data.

The TIFS first flew in 1970, and its first research project simulated the B-1 bomber's flying characteristics. During its long and successful career, the TIFS simulated many military and NASA aircraft, including the X-40, Tacit Blue, Space Shuttle, B-2, YF-23, and C-17. Civilian aircraft development projects included the Boeing Supersonic Transport (SST), MD-12X, and Indonesian N-250. It also served to train test pilots. The TIFS came to the Museum in 2008.

The TIFS was a highly-modified C-131B transport aircraft. Its piston engines were replaced by powerful turboprop engines, a second cockpit was attached to the nose, and large vertical fins were added to the wings. It was redesignated the NC-131H with the "N" indicating the aircraft had been permanently modified.

The TIFS could be configured with two different noses. On the left is the two-place forward cockpit containing reconfigurable controls and instrument displays. Onboard computers simulated the handling characteristics of various aircraft for pilots flying the TIFS from this cockpit. The original C-131 cockpit carried safety pilots who monitored the simulations and could take control in case of a problem.

The TIFS could be configured with two different noses. The second configuration (on the right) carried large prototype radars, infrared cameras, and other sensors. A crew station in the main cabin accommodated the system operators.

TECHNICAL NOTES:

Engines: Two 4,368 hp Allison 501-D22G turboprop engines

Stealth Aircraft

Stealth aircraft are designed and engineered for the purpose of avoiding detection by radar or any other electronic system.

NORTHROP TACIT BLUE

Built in the early 1980s in great secrecy, the revolutionary Tacit Blue aircraft tested advanced radar sensors and new ideas in stealth technology.

Tacit Blue proved that a stealthy aircraft could have curved surfaces—unlike the faceted surfaces of the F-117 Nighthawk—which greatly influenced later aircraft like the B-2. Tacit Blue's design also minimized the heat signature emitted from the engines, further masking its presence. Tacit Blue was aerodynamically unstable, but it had a digital fly-by-wire system to help control it.

With its low, "all-aspect" radar signature, Tacit Blue demonstrated that such an aircraft could loiter over—and behind—the battlefield without fear of being discovered by enemy radar. Using advanced sensors, it could also continuously monitor enemy forces (even through clouds) and provide timely information through data links to a ground command center. Moreover, these sensors functioned without giving away the location of the aircraft.

The Tacit Blue aircraft flew 135 times before the program ended in 1985. The aircraft was declassified and placed on display at the Museum in 1996.

TECHNICAL NOTES:
Crew: One

Engines: Two Garrett ATF3-6 high-bypass turbofan engines

Design Operational Speed: 287 mph/250 knots

Operating Altitude: 25-30,000 ft

Weight: 30,000 lbs

The Tacit Blue aircraft was nicknamed "The Whale" for its unusual shape. Also, the single engine intake on the top of the fuselage was reminiscent of a whale's blowhole.

NORTHROP-MCDONNELL DOUGLAS YF-23A BLACK WIDOW II

The YF-23A competed in the late 1980s/early 1990s against the YF-22A in the Advanced Tactical Fighter (ATF) program.

During the late 1970s, a new generation of Soviet fighters and Surface-to-Air Missiles (SAMs) prompted the US Air Force to find a replacement for the F-15 Eagle air superiority fighter. In 1986, the USAF awarded demonstration contracts to two competing industry teams—Lockheed-Boeing-General Dynamics (YF-22A) versus Northrop-McDonnell Douglas (YF-23A).

The Northrop YF-23A, unofficially named the Black Widow II, emphasized stealth characteristics. To lessen weight and increase stealth, Northrop decided against using thrust vectoring for aerodynamic control as was used on the Lockheed YF-22A. Northrop built two YF-23A prototypes.

In 1991, after extensive flight testing, the USAF announced that the Lockheed YF-22A won the air-frame competition. Northrop ended its ATF program, and the YF-23A on display came to the Museum in 2000.

TECHNICAL NOTES:
Crew: One

Engines: Two Pratt & Whitney YF119-PW-100s of approximately 35,000 lbs thrust each

Maximum speed: Approx. Mach 2

LOCKHEED-MARTIN RQ-3 DARKSTAR

The RQ-3 DarkStar was a highly-advanced, stealthy reconnaissance RPA (remotely piloted aircraft) designed for use in high-threat environments. Though it never entered production, the DarkStar was an important milestone in the development of even more capable RPAs which followed.

Designed to be fully autonomous, the DarkStar could take off, fly to the target area, operate its sensors, transmit its sensor imagery, return to base, and land without human intervention. Using satellite digital links to transmit sensor images, DarkStar could provide timely information across the globe. If needed, ground station operators could control the RPA from anywhere in the world using satellite links.

The DarkStar on display is the second of four built. The first DarkStar flew in 1996 but crashed on its second flight. The Museum's RQ-3 was modified to increase stability and flew in 1998. In January 1999, the Department of Defense ended the program because of cost and aerodynamic stability problems.

TECHNICAL NOTES:

Engine: One Williams-Rolls FJ44-1A with a takeoff thrust of 1,900 lbs
Cruising speed: About 288 mph

Range: About 575 miles

Endurance: About 8 hours

Service ceiling: 45,000 ft

Weight: 8,500 lbs

The Museum received this DarkStar, the only surviving one to have flown, in December 1999.

This guide features only some of the aerospace vehicles in the Research and Development Gallery. Visit the museum's web site at www.nationalmuseum.af.mil for a complete listing.

Suggested Resources

Videos available for loan through the National Museum of the USAF Education Division

High school and adult audiences from The Wings and Things Guest Lecture Series:

http://www.nationalmuseum.af.mil/Portals/7/documents/education/guest_lecture_video_loan_program.pdf

V022 Manned X-Planes: A History of Design, Development and Flight Testing by Mr. Jay Miller
Mr. Miller discusses 21 manned X-Planes, and puts special emphasis on the Bell X-1, in commemoration of the anniversary of the first supersonic flight (October 14, 1947).

V174 Recollections from a Pilot of Have Blue and Tacit Blue by Lieutenant Colonel Ken Dyson, USAF (Ret)
Lieutenant Colonel Dyson, one of the test pilots who demonstrated that an aircraft could operate close to the battlefield without being discovered by enemy radar, discusses his experiences regarding advances in stealth technology. As an Air Force test pilot, Dyson flew the F-100, F-101, F-4, F-15, F-104, B-1B, and the highly classified Have Blue and Tacit Blue.

V254 Pushing the Envelope: Vision and Genius in the R&D Gallery by Dr. Squire L. Brown
Dr. Brown discusses the unique collection of aircraft contained within the museum's Research & Development (R&D) Gallery, including the XB-70 "Valkyrie" and the rocket powered X-15. He delves into the fascinating stories behind these (and other) aircraft, including stories related to creative/innovative designs, air power strategies, and extraordinary performance.

For school audiences:

http://www.nationalmuseum.af.mil/Education/AVLoan.aspx

V051 Faster Than Sound

Grades 4-12—60 minutes

On Oct 14, 1947, U.S. Air Force Capt. Chuck Yeager flew the rocket powered Bell X-1 faster than the speed of sound. This video shows footage of dramatic test flights as well as how aircraft designers invented the wings, fuselages, and engines that pushed aircraft to supersonic limits. [NOVA Series]

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